Unit 1 Summary - Cause and Effect of Forces	
Unit Summary & Notes	*Utah SEEd **Strand 1** - Standard 1.1* *NGSS - Standard PS2.A* The overarching goal of this unit is to get students to understand how forces affect the motion of an object. This includes an analysis of balanced and unbalanced forces. Emphasis can be placed on free fall and kinematics (motion) at teacher discretion leading up to or during this unit. This unit can also be utilized as a "getting to know your students" exercise and includes introductory lab suggestions with this goal in mind. *Consider extending this unit based on the prior knowledge of incoming students.
Assessment Plan	At the end of this unit, students will assess the claims of *Porsche*. It is recommended that the teacher adjust the assessment to his or her classroom's needs by shortening or lengthening as needed. Please complete this **SURVEY** to request access to the summative assessments for the JSD High School Science Exemplar Units.

Unit 1 Pacing Guide - (70 minute class periods)	
This should take approximately **10 class periods** on a **block schedule**.	
Day 1	Engage: Phenomenon and unit introduction (example questions to go with phenomenon) - should be exploratory in nature. Introduce Rocket Challenge.
Day 2	Explore: Start the Rocket Challenge (build and test) - a similar activity can be substituted **(LG1A)**
Day 3	Explore and Explain: Rocket Challenge (revise and re-test, analyze results) **(LG1A)**
Day 4	Explore: Introduction to Spheros and Data Analysis Explain: Motion Nearpod **(LG1B)**
Day 5	Explore: Sphero Forces and Interactions **(LG1B)**
Day 6	Explain: Forces Nearpod and Forces Demonstration video **(LG1A)**
Day 7	Explore: Scooter Lab **(LG1C)**
Day 8	Explain: In-person: Which One Doesn't Belong Grouping Activity Virtual Option: Balanced vs. Unbalanced Forces Concept Builder and/or Which One Doesn't Belong Concept Builder **(LG1C)**

Day 9	Elaborate: Tumblebuggy and Fan Car Lab
Day 10	Summative Assessment - consider introducing the phenomenon for the next unit after the test concludes Please complete this **SURVEY** to request access to the summative assessments for the JSD High School Science Exemplar Units.

Day 1	
Activity Type	Engage
Learning Goal	N/A
Materials	**Engage:** SpaceX rocket launch (or any launch), materials to construct diagrams and graphs, grouping or cold-calling method to facilitate discussion
Activity Summary & Notes	The focus of today is dual. First, you want to get students to think about how engineers account for forces acting on an object. Second, you want to focus on teaching students the skills to properly analyze a phenomenon and represent their thinking verbally, pictorially, and graphically. Before teaching this lesson, come up with a list of questions that can act as guideposts for students. Use the learning goals for inspiration. An example question might be "draw a graph that represents the movement of the rocket" or "draw a diagram that shows all of the forces acting on the rocket". You can also ask questions such as "what factors do engineers consider most important when designing a rocket". Don't be afraid to extend your questioning past the bounds of the video! You can use this slideshow to get some examples on how to lead the discussion and this sample student handout to give you some ideas. Take time to ask a lot of questions of students and help them practice those deeper thinking skills. Consider doing a "model" video for phenomenon during this lesson. This is your chance to set your students up for success and learn a bit about their prior knowledge! Showing the full version of the launch is a great follow up lesson or activity. It has the real-time data on the screen. Fast forward to around 21:00. Falcon Heavy Full Length Launch Video Don't forget to tell your students to bring supplies for building their bottle rockets next time. You can take them outside at the end of class if you have time and show them how the launchers work. *Teachers will most likely not spend an entire class period on phenomenon in future units. The goal is to focus on developing procedures and getting students comfortable with discussing scientific topics.
Connection to Anchor	N/A

Phenomenon	
Formative Assessment	Have students submit a diagram of the scenario and a graph. You may ask students to complete a worksheet model and a list of targeted questions in addition to classroom discussion.

Day 2 and 3	
Activity Type	Explore
Learning Goal	*1B: Describe the motion of an object in terms of its position, speed, direction, and whether or not the object is accelerating.*
Materials	**For Lab:** student handout, bottle rocket launcher, two plastic 22 oz soda bottles per group (verify the fit before build to your particular launcher), clay, fin material, bicycle pump or air compressor, heavy-duty tape, water, protractor to measure launch angle*, materials for modification/repairs on the fly*, student safety goggles* *suggested
Activity Summary & Notes	Students will explore the steps of the scientific method to build and modify a bottle rocket. Use this lesson as an introduction to forces (air resistance on the rocket, air pressure to launch, etc) Day 1: Students should leave one bottle uncut and use the second for a nose cone. Inside the nose cone, place about 50 g of clay. Attach fins to the rocket for stability. Use duct tape to adhere pieces together. Day 2: Student focus should land on improving their rocket distance or hang time by manipulating one variable at a time (number of fins, angle of launch, amount of water during launch, etc.)
Connection to Anchor Phenomenon	Lead a discussion after this activity regarding how scientists and engineers take forces into account designing rockets like the Falcon Heavy
Formative Assessment	Grade through the student hand-out, paying close attention to the guiding questions 3,4, and 5. Possible class discussion about these topics to formatively assess student understanding

Day 4	
Activity Type	Explore

Learning Goal	*1B: Describe the motion of an object in terms of its position, speed, direction, and whether or not the object is accelerating.*
Materials	**For Explore:** Introduction to Spheros and Data Analysis **For Explain:** Motion Nearpod: https://share.nearpod.com/e/FEaUJKnHrab (must login to your own account) **Optional Student Practice:** Concept Builder: Match that Graph
Activity Summary & Notes	If students have never used Spheros before, you may want to have a 20 minute period where they can download the app, learn how they work and "play" before getting started. Assign each group to change their light to a specific color so that they always know which Sphero is theirs. You also need to show them how to "Aim" the first time they use them. Once they have had a chance to figure out how they work and play with them, start on the lab: Introduction to Spheros and Data Analysis . You will probably need to show the students how to write the first couple of lines of code and then run the code in front of the whole class before sending them off on their own. (To do this, go into "Programs" and create a new program using "Blocks", drag up the "Roll" block and enter the speed, heading and time, then press "Start", finally to view the graph, click on the three dot menu and select "Sensor Data." This should bring up a series of graphs the Sphero plotted while running the program which the students will use when answering the analysis questions. You may need to show them that they can turn their phone sideways to view the entire graph and that they can toggle off and on the "total" "x" and "y" options. This lab will take most but not all of the class period. When students finish the lab, have them complete the Motion Nearpod, which covers some of the basic terminology that students should now be familiar with. Work to draw parallels with the Falcon Heavy video and to the rocket launch lab. The Nearpod can be finished as homework if they don't finish it all in class. Some students may need some additional practice and can work on part 1 of the concept builder to help cement learning. It is helpful for students to see the teacher complete one question of each level before they attempt it themselves. (It is not necessary to purchase a subscription to physicsclassroom to utilize the concept builders, but it is helpful).
Connection to Anchor Phenomenon	Make connections during the nearpod. Ask students to revise and improve their motion graphs from the engage portion.
Formative Assessment	Evaluate student graph re-works. Exit ticket or quiz

Day 5	
Activity Type	Explore
Learning Goal	*1B: Describe the motion of an object in terms of its position, speed, direction, and whether or not the object is accelerating.*
Materials	**Explore:** Sphero Forces and Interactions
Activity Summary & Notes	Begin with the Sphero Forces and Interactions lab. This is a really great exploration, since you are giving the students the data and having them create it in the lab. Show the students how to write the first few lines of code on Graph B and run the program as a whole class before sending them off on their own. (To do this, go into "Programs" and create a new program using "Blocks", copy the code that's on the paper, then press "Start", finally to view the graph, click on the three dot menu and select "Sensor Data." This should bring up a series of graphs the Sphero plotted while running the program. The velocity graph is toward the bottom. If you are programming the Spheros to run in a straight line (forward and backward), you will want to look at the y-direction graph only. Ask the students how they would complete the code to finish the graph. If you want to show the graph to your students and have a discussion about why the graph on the Sphero is not smooth like the one on the worksheet at this point, you can, or you can post it to the class to think about reasons why it doesn't look exactly smooth. This lab will take almost an entire period, but if you finish early, you can have the students finish the nearpod and/or continue working on the concept builder from last time. Work to draw parallels with the Falcon Heavy video and to the rocket launch lab.
Connection to Anchor Phenomenon	Make connections during the notes. Ask students to revise and improve their motion graphs from the engage portion.
Formative Assessment	Evaluate student graph re-works. Exit ticket or quiz

Day 6	
Activity Type	Explain
Learning Goal	*1A: Describe the forces acting on an object.*
Materials	**Explain**: Forces Nearpod OR Forces Webquest **For Student Presentations:** Forces Demonstration Student Instructions, students will need to have access to a video recording

	device. Alternatively, you could have student groups perform a demonstration of forces for the class instead of a video recording.
Activity Summary & Notes	Begin with the forces webquest assignment. This assignment will ask students to explore the physics classroom website and they will take notes, solve problems, and draw FBDs with assistance. This will act as a primer for further discussion and should be treated as exploratory in nature. This should take students anywhere from 40 - 60 minutes to complete. Then, assign students the forces demonstration. This activity will require students to use their forces webquest notes to demonstrate six different examples of forces. You may assign this to individual students (require less forces) or to groups of students (require the full six).
Connection to Anchor Phenomenon	Students should now be able to begin identifying the forces acting on the Falcon Heavy/Have students revise and improve their diagram of the Falcon Heavy as a proper FBD with appropriate force labels and vector sizes
Formative Assessment	Forces Demonstration Evaluate student diagram revisions Exit ticket or quiz

Day 7	
Activity Type	Explore
Learning Goal	*1C: Explain how changing the force acting on an object or changing the mass of the object affects the acceleration of the object.*
Materials	**For Lab:** Scooter Lab (in person) -OR Scooter Lab (virtual) **Additional Virtual Options:** PHET forces lab (virtual...either version 1 or version 2, depending on student needs) Materials needed for the in-person scooter lab: tape measure or meter sticks, scooters or skateboards, 50 N spring scales, timer, masking tape, bathroom scale or force plate
Activity Summary & Notes	The data collection for the scooter lab takes about half the class period and the analysis and questions take about half as well, so students should be able to finish or almost finish before the end of the period. The students should work in groups of at least 4 so that they have someone to ride the scooter, someone to time, someone to call out when they cross the tape lines and someone to pull. For the virtual option, choose either the version 1 lab (which focuses on balanced vs unbalanced forces) or the version 2 lab (which focuses on the mathematical relationships between force,

	mass, and acceleration). Schedule in some time to discuss the results of the lab with students.
Connection to Anchor Phenomenon	You can lead a discussion about how engineers take balanced and unbalanced forces into account when designing rockets. Additionally, you can now analyze the rocket launch moment by moment in terms of balanced and unbalanced forces...consider showing the full length version of the launch on this day and looking at the numerical on-screen data. Fast forward to around 21:00. Falcon Heavy Full Length Launch Video
Formative Assessment	Use your discussion with students as your formative assessment. Do they seem to understand that a balanced force means the object is not accelerating? Exit ticket or quiz

Day 8	
Activity Type	Explain
Learning Goal	*1C: Explain how changing the force acting on an object or changing the mass of the object affects the acceleration of the object.*
Materials	**Explain (if students need help with data analysis/force diagrams)**: In-person: Which One Doesn't Belong Grouping Activity Virtual Option: Balanced vs. Unbalanced Forces Concept Builder and/or Which One Doesn't Belong Concept Builder **(LG1C)** **OR** **Explain (if students need help with calculations):** Solving for Newton's Second Law notes **For Student Practice:** Solving practice version 1 or version 2
Activity Summary & Notes	If you find your students need help on analyzing data and force diagrams, try this fun matching/grouping activity (Which One Doesn't Belong Grouping Activity) based off of the concept builder. Print off the cards in advance on cardstock and cut them out. Recommended to print enough sets that students can work in groups of three. (Suggestion: print them in different colors so the sets are less likely to get mixed up.) On the last page of the document are the grouping activities for the students. First, ask the students to sort and group the cards (don't tell them how to group the cards, just see what they come up with on their own.) Talk about how there are multiple correct solutions to this problem. Next go down the list and ask students to group the cards according to the requirements. Groups that finish early should help their neighbors. Encourage discussions between the teams. This activity will really help bring all of the concepts

	together and solidify student understanding. **OR** If you find your students need help with the mathematical relationship between force, mass and acceleration, first, begin students on the Balanced vs. Unbalanced concept builder. It is suggested that the teacher model how to solve each level to students. This concept builder will tie in concepts from all three learning goals. Then, cover the notes and the basics of solving for force problems. We suggest that the teacher model extra problem sets with students on the whiteboard before assigning the following practice problem sets. Next, choose which version of practice you want students to complete. Version 1 focuses on the effect that different gravitational accelerations affect the force of gravity acting on an object. This version is better suited to more advanced students as additional practice. Cut out the planets with their g values and place them around the classroom. Students must "visit" the planet to calculate their weight on that planet. Version 2 has a much broader focus and encompases solving for balanced and unbalanced forces and how they affect the object's acceleration.
Connection to Anchor Phenomenon	You can lead a discussion about how engineers take balanced and unbalanced forces into account when designing rockets. Additionally, you can now analyze the rocket launch moment by moment in terms of balanced and unbalanced forces.
Formative Assessment	Exit ticket or quiz: *students really struggle with the concept of acceleration. Make sure students get that an unbalanced force will cause an object to accelerate, but a balanced force does not mean an object stops moving.

Day 9	
Activity Type	Elaborate
Learning Goal	*1A-1C*
Materials	**For Lab:** Student Handout, tumblebuggies (or automatic constant velocity car), meter sticks, timers, fan cars (or constant acceleration car - a good wind-back car can substitute), pennies/pokerchips/an

	item to mark distance each second
Activity Summary & Notes	This activity can be modified to fit the student. For example, teachers can have students do the tumble buggy portion of the lab, then make predictions for the fan car portion of the lab. Additional questions can be added to extend the lab or portions can be simplified. This lab works best when both carts are demonstrated and students know that the tumble buggy should represent constant velocity while the fan car constant acceleration. To emphasize this point, have students predict the shape of the distance-time graph for each vehicle before the lab.
Connection to Anchor Phenomenon	A discussion of the initial rocket phenomenon can function as a general review for the test. Take care to use vocabulary developed during this unit. Suggested students do a re-analysis of the initial phenomenon.
Formative Assessment	*N/A*

Day 10	
Activity Type	Summative Assessment
Test Summary & Notes	Please complete this **SURVEY** to request access to the summative assessments for the JSD High School Science Exemplar Units. Before administering this test, please familiarize yourself with the given proficiency scales for the unit. You may want to develop a rubric to aid in grading. Prepare students for the style of test. While some students might be familiar with a more open-ended test style, for others this will be their first time. Student success can come in a variety of ways for this test. Be looking for student application of skills learned during the test for higher scores and be open to students who approach the problem from a variety of different angles. During a block period, it is suggested that you plan to cover the new phenomenon for the next unit. Depending on student test pace, however, you may not be able to fit both the test and new phenomenon, and this is okay. Allow for some flexibility.